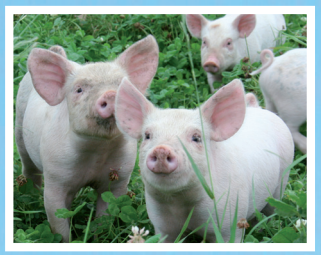


The Contribution of Organic Farming to Public Goods in Denmark

Knowledge Synthesis 2015



ICROFS
International Centre for Research in Organic Food Systems

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to Public Goods in Denmark
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About ICROFS
ICROFS is a research centre without walls, which coordinates research within organic farming and food systems at a number of universities and research institutions in Denmark and abroad.

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The Contribution of Organic Farming to Public Goods in Denmark

In Denmark, the organic sector has broad political support, and the consumers' demand for organic products is soaring. This is a sign of great interest in the organic production method that aims at developing sustainable farming, which takes nature, biodiversity, environment, animal welfare etc. into consideration and prioritises high food quality.

This has been expressed by the international organic umbrella organization, IFOAM, in their four principles on ecology, health, justice and precaution, which inspired the EU Organic Regulation from 2007 (EC 834/2007) that regulates the organic production in Denmark. International and Danish analyses have previously shown a certain degree of compliance with the organic principles but the degree of compliance may vary depending on the farm type and management.

The purpose of this knowledge synthesis is to create an overview of the existing knowledge on the contribution of the Danish organic sector to different public goods. This may provide politicians and other stakeholders with a better foundation for using organic farming as a tool for the society, based on scientific documentation.

The knowledge synthesis was coordinated by ICROFS' secretariat and involved a large number of scientists and experts, to whom we owe great thanks for a dedicated effort within a very short period of time. The work was initiated with a conference in December 2014, where 62 researchers and experts contributed to the initial delimitation of the topics as well as to the identification of the most essential scientific documentation within the area.

Subsequently, ICROFS appointed coordinators for each of the subject areas and together with them ICROFS made a gross list of co-authors. Approx. 75 researchers and experts have thus been involved in the preparation of the knowledge synthesis. In March 2015, the first draft for the structure and contents was presented at a meeting for relevant stakeholders with an interest in public goods in order to get their comments and ideas for the future work that was to be carried out. In parallel, the authors made this first, short summary of the knowledge synthesis, which was presented at a conference with politicians and other stakeholders at Christiansborg (the Danish Parliament) on 22 April 2015. The brochure was revised and reprinted in October 2015, and the knowledge synthesis itself (more than 400 pgs. in Danish) is published in November 2015.

See the knowledge synthesis (in Danish)
http://icrofs.dk/fileadmin/icrofs/Diverse_materialer_til_download/Vidensynte_WEB_2015__Fuld_laengde_400_sider.pdf

October 2015

Kirsten Lund Jensen
Chairman of ICROFS' Programme Committee

Purpose and Background for the Knowledge Synthesis

The purpose of this knowledge synthesis was to gather and structure the existing knowledge on the contributions, inadequacies and development potential of organic farming in relation to public goods in Denmark.

In this context public goods are defined as goods or services which society wants its citizens to have access to that are normally not "tradeable" (on a market). However, many of these services are only free in the sense that others ensure their availability. The public goods, which organic farming can contribute to, include biodiversity, good natural and environmental conditions, climate mitigation, human and animal health and welfare as well as development of food industry and rural districts. Additionally, it is a public good to secure the use of energy and other resources, in a both efficient and sustainable way. These aspects are not automatically ensured by the market forces.

The contribution of organic farming to the public goods is not necessarily reflected in the prices to be paid for the organic products. In many cases it is very challenging to valuate such effects, and furthermore the valuation may vary from one person to another.

The organic production in Denmark is regulated by the EU Organic Regulation and Danish rules as well as agricultural support schemes, which impose additional requirements on organic producers to obtain special subsidies.

The Organic Regulation lies down objectives and principles for the organic production as well as specific demands. Thus, the potential contribution of organic farming to the public goods is expressed in the organic principles, while the specific requirements in the EU Organic Regulation indicate the minimum contribution of organic farming to the public goods.

Within some areas, the organic principles and specific requirements draw in the same direction and synergies may be achieved. The requirement for access to grassland in the summer for livestock thus ensures better animal welfare, at the same time contributing to improvement of the soil fertility as well as supporting improved biodiversity.

Other requirements may lead to conflicting effects in relation to the public goods and cause dilemmas. Sows on grass, for instance, ensures better animal welfare but at the same time causes higher nitrogen leaching. So far it has been difficult to take these many-sided effects of organic farming into consideration when evaluating organic farming as a tool. Therefore, methods are needed for the evaluation of how and where (geographically) the different organic farm types may contribute best to a wide range of public goods.

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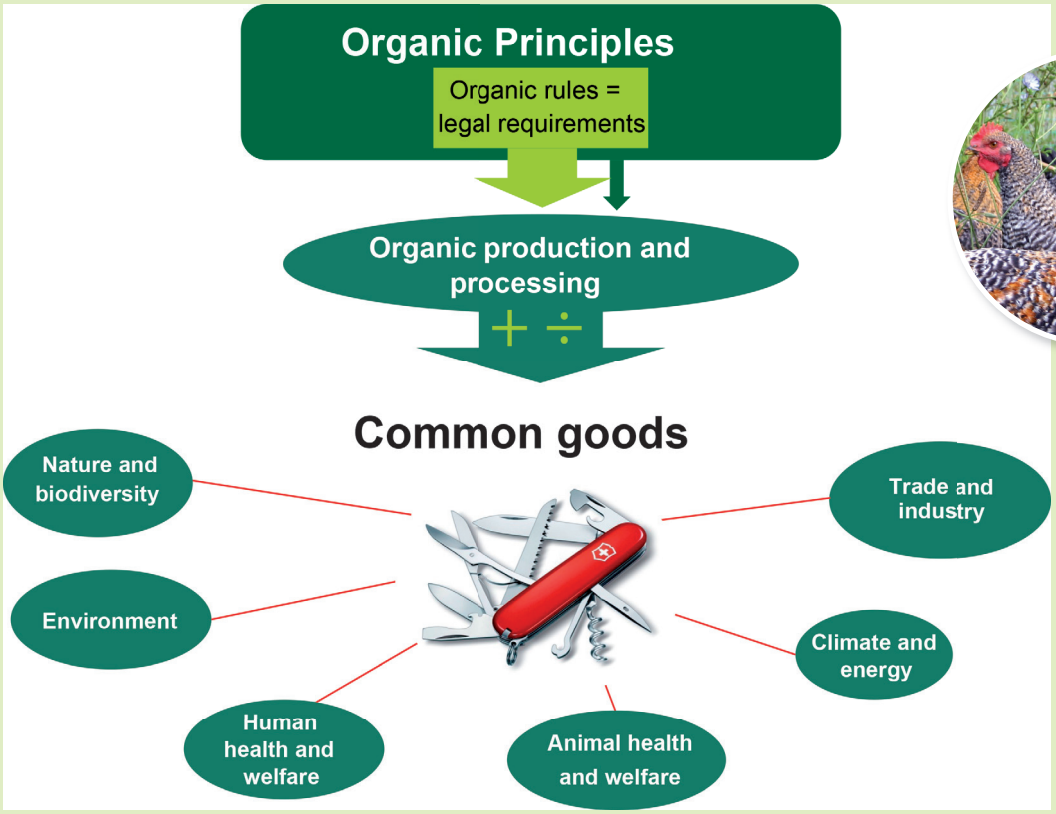

Current Status of Organic Farming in Denmark

Organic production is experiencing a positive development of demand as well as production. However, there is a need for more producers of organic pigs, eggs, chickens as well as apples and pears, etc. The revenue in Danish retail has almost tripled from 2005-2014, where it amounted to DKK 6.2 bn. corresponding to an increase of approx. 6 per cent compared to 2013. Sales to public kitchens, canteens and restaurants through catering companies have also increased and have topped one billion DKK. Total sales of organic goods in 2014 amounted to 8.0 bn. DKK corresponding to a consumption of 1,450 DKK per Dane. Denmark has the largest organic market share in the world with organic food accounting for 7.6 per cent of the total food retail sales.

Furthermore, exports have increased with giant strides within the last ten years and with an increase of 31 per cent compared to the year before, the export of dairy products totalled 1.5 bn. DKK in 2013. Pig meat accounts for the majority of the Danish organic exports. Imports have also increased year by year and in 2013 it totalled 1.8 bn. DKK. In 2014 a further increase of the import is expected – mainly due to the increased sales through catering where the demand for fruit and vegetables is progressing. Despite of a large Danish production of among others carrots, potatoes, tomatoes and lettuce, it is a big challenge for the Danish vegetable growers to compete with the prices of the imported goods.

The positive development in sales of organic products has not triggered an equivalent expansion of the organic farm area, which has only increased from 150,000 acres in 2005 to 176,323 acres in 2014. This is in part due to the previously seen surplus production of organic milk, for which reason the dairies have not been willing to take in new producers. In 2014, 482 million kg of organic milk was weighed in by the dairies. In recent years, this level has remained the same but now Arla Food has announced that it wishes to increase the weighed-in amount with 150-200 million kg of organic milk up until 2017. A significant part of the organic farm area is occupied by dairy farms and production of feed for the organic dairy herds. In the same period the area with organic cereals has more or less remained the same amounting to 50,000 hectares, while there has been an increase in the import of cereals and feedstuffs.

The demand for organic pig meat is high and the supply to the EU market is scarce. Therefore, the company, Friland, which markets organic meat, wishes to increase the number of slaughtered organic pigs by 15-20 per cent per year in the coming years. However, despite good market prices for pigs, difficult financing conditions make it quite challenging to reach this goal. In 2014, 110,000 organic pigs were slaughtered.

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The poultry industry has also gone through a positive development, the biggest success story being organic eggs. With a total of 12.2 million kg, organic eggs accounted for one fifth of the total amount of eggs weighed in 2014. The production of broiler chickens is growing, as approx. 700,000 organic chickens were slaughtered in 2014 and in addition to that 110,000 organic ducks. The Danish poultry industry would like to welcome more organic producers in order to be able to meet the increased demands, but also within this sector financing is a big challenge.

Finally, it should be mentioned that organic aquaculture is developing rapidly from year to year. Thus, the organic production has increased from approx. 350 tons in 2008 to 1,100 tons in 2014, and it is expected to rise to approx. 5,500 tons in 2015. Especially the production of organic blue mussels grown on lines will be multiplied in 2015. In addition, a number of fish farms and aquaculture plants are on the waiting list to have their production converted to organic production.

Organic share of the total agricultural production within different farm types (2014)

Egg production	20 per cent
Vegetables	18 per cent
Dairy production	10 per cent
Crop production	7 per cent
Broiler chickens	1 per cent
Pig production	0,5 per cent

Source: Statistics Denmark and the Danish Agrifish Agency.

Quantitative composition of the consumption of organic food products (2014)

Dairy products	56 per cent
Vegetables	13 per cent
Grain, bread, flour etc.	13 per cent
Fruit	5 per cent
Eggs	3 per cent
Meat	2 per cent
Other	8 per cent

Source: Statistics Denmark, Retail sales of organic products.

Nature and Biodiversity

RESEARCH, DEVELOPMENT AND ADVICE WITHIN THIS AREA SHOULD INCLUDE:

- Development of methods for the evaluation of the contribution of nature and biodiversity to the farm land and mapping of the limiting conditions.
- Documentation of the impact of biodiversity promoting initiatives on the farm, among others optimisation of scale in time and space.
- Development of incentives, motivating the farmer to increase the biodiversity.
- Development of a concept for 'the farmer as manager of the nature' to enhance the considerations for biodiversity.
- Studies on the potential for integration of biodiversity considerations into future organic production systems.

Denmark is a relatively densely populated country and there is not much space for nature in the Danish landscape. Arable land, infrastructure and cities make up three quarters of the land area in Denmark, of which the farmed area makes up 62 per cent. Plant and animal species are disappearing at an alarming rate and today approximately one fourth of the Danish species within each category group is threatened with extinction. Furthermore, many natural habitat types are threatened due to ammonia evaporation, drainage and pesticide application.

On the international level, biodiversity has been a focus area for a number of years, but Denmark did not get a biodiversity strategy until 2014. In order to achieve the goals of this strategy, larger and more interconnected natural habitats, more small biotopes and extensively farmed land areas must be established, just as better protection and care of such areas is necessary. The EU Organic Regulation prohibits the use of synthetic pesticides and prescribes the use of organic fertilizers including animal manure. These requirements are important in order to obtain better biodiversity in fields and biotopes close to fields. The requirement to let out cattle to graze may also have a positive effect on the biodiversity. However, mechanical weed control may have a negative effect on birds nesting in the field and animals living in the soil. The latest research proves that 'system-independent' factors such as space for natural habitats, lower cultivation intensity and long-term organic management are important in order to achieve significant improvements of the biodiversity.

In the fields and biotopes close to the fields of organic farms there are, on average, 30 per cent more wild plant and animal species than on conventional farms. The organisms that benefit from organic farming are among others animals living in the soil and microorganisms, pollinating insects and natural enemies of pest insects and diseases. These organisms contribute to important functions in the ecosystem such as the fertility and soundness of the soil, the soil texture, the pollination and plant protection. All of these functions are extremely important for the maintenance of sustainable farming. Scientific evidence proves that increased diversity entails increased functionality in the form of more efficient pollination and regulation of pests and plant diseases, but today the potential for improvement of the biodiversity on the organic farms is not fully exploited.

There is a need for more knowledge about specific systems and organisms with a view to the choice of scale and initiatives and also to be able to document the importance of biodiversity in relation to important ecosystem services – and to the production value as well.

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Differences directly due to the organic rules Consistent differences	Differences derived from the organic rules Differences depending on the type of farm etc.	Differences independent of the production system Non-consistent differences
• No pesticides • Use of organic fertilisers instead of mineral fertilisers • Lower N-level • Grazing for cattle • Free-range pigs and poultry	• Crop diversity and types: - Crop producers: Often several types of crops - Livestock farms: Often only a few types of crops, but more multi- annual feed crops (undisturbed) • Soil treatment: - Mechanical weed control - Pastures - Reduced soil treatment • Less dense crops (due to lower N-level)	• Field size • Small size biotypes - quantity (field size, geography) - quality (pesticides, fertiliser and age as organic) • Management of permanent grassland

Figure:
Variations in the management conditions of organic and conventional farms grouped into whether the differences between organic and conventional farming depend on the organic rules, or whether they are independent of these.

Environment

The environmental impact of the agricultural production in Denmark is significant. Therefore, political action plans and legislation have been implemented in the EU and in Denmark to protect the ground water, surface water, nature and air against pollution from pesticides, nitrates, phosphorus and ammonia to prevent the negative impact of agriculture on the environment.

The organic production is based on the principles of limited use of external input of non-renewable resources and recycling of organic waste products, and the production method specifically demands multi-annual crop rotations with legumes and green manure crops. Mineral fertilisers, synthetic amino acids and most pesticides are prohibited, and feed based on GMOs is not allowed either. In addition, livestock shall be grazing a large part of the year and daily offered roughage. In order to obtain organic subsidies, the farmer is only allowed to apply animal manure corresponding to 100 kg of utilisable nitrogen (N) per hectare. A higher subsidy can be obtained if an application limit of max 60 kg of utilisable N per hectare is not exceeded.

Organic agriculture can protect the ground water, the surface water and nature against pesticide pollution. The leaching of nitrate from organic milk production, which accounts for 10 per cent of the total Danish production of milk and occupies approximately 70,000 hectares of land, is lower than from conventional milk production. This is due to lower livestock density and N-application and may contribute to reduced amounts of nitrate in the surface and groundwater. Moreover, organic farms have more diverse crop rotations with a larger proportion of perennial crops (clover-grass and alfalfa), which help maintain the organic matter content in the soil and thus also the cultivation suitability - especially of low-carbon clay soils.

Organic crop production farms incl. horticulture have the same level of nitrogen leaching per hectare as in conventional production, while the level of nitrate leached from organic pig farms is higher than from conventional farms, i.a. because of the point pollution from the outdoor production of pigs. The ammonia evaporation from organic slaughter pig stables is higher than from conventional pig stables, partly due to requirements for more space per animal. Moreover, the feed contains a higher level of nitrogen, since synthetic amino acids are not allowed, which causes an amino acid composition that is not ideal.

Organic agriculture is better at recycling nutrients within the farm than conventional farms, but it contributes less to the recycling of organic waste from the cities, because there are strict requirements on the quality of non-organic fertilisers and soil improvers in the EU Organic regulation.

RESEARCH, DEVELOPMENT AND ADVICE WITHIN THIS AREA SHOULD INCLUDE:

- Development of crop production systems with improved retention of nitrogen in the root zone during the winter, and development of plant varieties with higher nutrient use efficiency.
- Optimisation of the amino acid composition in feed for monogastric animals and development of stable systems with less ammonia evaporation.
- Development of waste handling and collection systems that efficiently and without risk can return organic waste products to agriculture.
- Development of robust and cost competitive crop varties.

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Energy and Climate

Energy and climate are important public goods. Security of energy supply has high political priority and vital societal values are affected, when the weather runs amok. At the same time, ambitious political goals have been set for the reduction of greenhouse gasses and the energy consumption. Thus, Denmark is expected to reduce the emission of greenhouse gasses by 30-40 per cent up until 2030.

Neither the EU nor Danish Organic Rules include specific requirements regarding climate or energy. The EU Organic Regulation has a general objective of sustainable production and requires a responsible utilisation of energy and natural resources, and it also contains principles of limited use of external inputs and minimisation of the use of non-renewable resources. In 2012 agriculture contributed with approximately 20 per cent of the greenhouse gas emissions in Denmark and organic farming accounts for about 5 per cent of these emissions.

RESEARCH, DEVELOPMENT AND ADVICE WITHIN THIS AREA SHOULD INCLUDE:

- New cultivation systems, which may increase the carbon sequestration and reduce the emission of nitrous oxide by means of new crop rotations, catch crops and reduced tillage cultivation systems.
- New feeding systems for ruminants, which may reduce methane from the digestion process.
- New stable systems and manure handling systems for reduction of the methane emissions, which in combination with catch crops and plant wastes treated in biogas plants may increase the bio-energy production.
- Joint production of food products, protein-rich animal feed, fertilisers and energy based on multi-annual crops such as clover grass in combined bio-refinery and biogas plants.
- New technologies for the reduction of the energy consumption, comprising efficiency improvement and electrification of stable and field operations.
- Use of biogas as fuel in tractors and agricultural machinery and for transportation of agricultural products.

The greenhouse gasses from agriculture includes nitrous oxide (the larger part), which comes from nitrogen turnover in the soil, and methane, which mainly originates from cows' digestion and from storage of animal manure. In addition, there are emissions from the use of fossil energy and CO2 from drained wet meadows.

The climate impact is a challenge to organic agriculture as the crop production per hectare and the animal production per stable area is smaller than in conventional agriculture. The greenhouse gas emissions from organic livestock production are therefore higher per kg product, but lower per hectare than in corresponding conventional production. The emission from organic plant products is often at the same level per kg product as conventional products when the emissions from import of commercial fertilisers and other additives are taken into account.

Changing the organic cultivation practices, the feeding of the farm animals and the handling of farmyard manure may mitigate the climate change, especially if combined with bio-refinery and biogas production. Likewise, the use of renewable energy and energy saving technologies may reduce the energy consumption – initiatives that may inspire the entire agricultural sector.

In order to obtain considerable reduction in the climate impact and fossil energy consumption there is an urgent need to find, develop and support possible solutions.

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Human Health and Welfare

Human health and welfare is in high focus not only on the political agenda but also among people in general. Sickness and lack of quality of life involve high costs, not only for the individual but for society as well. Often health is equated with the absence of disease, but other health concepts also include mental health, quality of life as well as improved disease resistance. Comprehensive legislation shall ensure that food products are not harmful to humans because of undesirable substances and pathogens, and official diet advice shall improve public health through a healthier diet.

One of the objectives of the EU Organic Regulation (EC) 834/2007 is to secure the production of high quality food products that are not harmful to human health and welfare. Thus, it builds on the precautionary principle, for which reason the use of GMOs and synthetic pesticides is prohibited, and the use of food and feed additives and processing aids is much restricted. Furthermore, the rules for medication of animals, including the use of antibiotics, are very restrictive. As far as possible, food products should be processed by biological, mechanical or physical methods, and certain methods are completely prohibited, e.g. disinfection by ionising radiation. Roughage shall be offered to all livestock species as well as access to grazing for cattle, pigs and poultry. The above-mentioned rules may potentially affect the composition of the food products and thus the health of humans.

The composition and quality of protein, fatty acids, vitamins and minerals in organic food products may be favourably compared to similar conventional products. However, other factors such as soil type, climate, crop variety and genotype often have greater influence. The finding of an increased content of secondary metabolites (bioactive substances) in organic crops as well as a different composition of fatty acids in organic animal products compared to similar conventional products has attracted a lot of attention in relation to human health. However, other studies did not identify such differences, for which reason no clear conclusions may be drawn.

By eating organic food, consumers are to a lesser extent exposed to undesirable substances in the food such as pesticides, medical residues and food additives but it is very difficult to document the health effects of this. The level of Salmonella is lower in organic pigs than in conventional pigs, while the level of Campylobacter in organic poultry is higher. The level of antibiotic-resistant E. coli bacteria is lower in Danish organic pigs than in conventional pigs. However, there is great individual variation between farms within the two productions systems.

New studies indicate that organic consumers follow the official diet composition recommendations to a greater extent that the average consumer. In recent years, a considerable organic conversion of commercial and public kitchens to organic food has taken place, which in general has improved the dietary composition. However, it is still difficult to document a direct positive effect of the changed and organic diet on human health.

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RESEARCH, DEVELOPMENT AND ADVICE WITHIN THIS AREA SHOULD INCLUDE:

- Studies on how an organic diet affects human health, including a more clear definition of the health concept.
- Optimisation of the primary production with regard to health-promoting substances in the raw materials and studies on how the processing of food affects the health quality.
- Evaluation of the effect of the precautionary principle on human health, including the importance of a simultaneous exposure to low levels of several pesticides and adjuvants (the cocktail effect).
- Studies on the effect of the organic production method on resilience of both animals and crops to infection, as well as studies on the most important transmission pathways for bacteria disease from animals to humans.
- Studies on what 'eating organic' means to 'feeling healthy' and the effect of this on the resilience of the individual to resist or live with diseases.

Animal Health and Welfare

RESEARCH, DEVELOPMENT AND ADVICE WITHIN THIS AREA SHOULD INCLUDE:

- Development of breeding strategies targeted at organic livestock production, i.e. animals with high vitality and good health and welfare including use of local breeds.
- Development of stable systems supporting an even higher degree of natural behaviour and health of the animals, e.g. more outdoor access and late weening of offspring.
- Management strategies for prevention of diseases, reduction of mortality (especially suckling piglets, calves, poultry and fish) and reduction of the use of antibiotics.
- Strategies for the prevention of intestinal worms in organic laying hens, slaughter pigs and calves on outdoor areas.
- Advice concerning improvement of animal health and welfare targeted at the needs of the organic farmers.

Many Danes are interested in the animal welfare in livestock production and are critical towards keeping the livestock indoors all year round on limited space per animal. The public also has strong focus on the use of antibiotics and there is a widespread concern that increased occurrences of bacteria that are resistant to antibiotics may make humans more ill.

The EU and Denmark have quite detailed legislation aimed at securing livestock a minimum level of animal welfare. There are species-specific rules, among other things setting minimum requirements for space, indoor and outdoor area, access to roughage and water, supervision and treatment of sick animals.

The animal welfare in the organic livestock production differentiates itself from the typical conventional livestock production through requirements to ensure that:

- the animals (expect for fish) have access to grazing and/or outdoor areas.
- the animals have more space per animal and thereby better opportunities to unfold species-specific behaviour
- calves and suckling pigs are weaned later and broiler chickens are slaughtered at a higher age
- all animals, ruminants and monogastric animals, have permanent access to roughage.

Furthermore, there is a number of organic rules that act to keep the animals healthy, prevent treatment- requiring illnesses and minimise the use of antibiotics.

Access to outdoor area and plenty of space per animal are conditions that the consumers typically associate with good animal welfare, and the majority of the dairy cows, pigs and poultry seen in the landscape are organic. In organic pig production the use of antibiotics is considerably lower than in the corresponding conventional production. In organic dairy production the use of antibiotics is also lower than in conventional dairy production, and a potential lowering of it by another 50 per cent has been identified.

The size of the organic animal herds is constantly growing and the production output per animal is increasing just as in conventional livestock production. Consequently, a development of the organic livestock production with regard to the maintenance and improvement of the animal health and welfare is needed. New types of organic farming are also developed, typically on smaller livestock farms, where there seem to be an unexploited potential for further improvement of the animal health and welfare. The transition to 100 per cent organic feed for pigs and poultry (from allowing 5 per cent non-organic protein feed in the feed ration by the end of 2017) requires increased focus on securing a sufficient protein supply and an optimal amino acid composition for the young animals.

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Industry and Rural Areas

RESEARCH, DEVELOPMENT AND ADVICE WITHIN THIS AREA SHOULD INCLUDE:

- Studies on possibilities and barriers in organic processing, distribution and sales as well as on the influence on employment within the entire value chain.
- Studies on innovation processes and entrepreneurship in an organic context.
- Studies on organic farming and processing as a tool for rural area development

A significant part of the added production costs of organic food products is covered by higher prices and thus helps paying for the contribution of organic agriculture to the public goods. This is why the market for organic products is important in this context. The agricultural production and part of the processing takes place in the rural areas, and the employment that it produces is very important to society. Country life, branding of a rural region and the cultural encounter between the urban and rural are important aspects organic agricultures contribution to rural development. At the same time, the growth and innovation taking place within the organic sector is an important contribution to the public goods.

The EU policy on rural area development prioritises environment, competitiveness, landscape and quality of life in the rural areas as well as diversification of the agricultural economy. Growth strategies for the food sector aim at promoting sustainable and resource efficient food production. Organic production may contribute to both. The objectives and principles of the total set of organic rules motivate cross-disciplinary thinking and facilitate innovation in the value chain as well as socially.

Organic food production targets the part of the food market that is expanding due to the consumers' increasing demand for products that fulfil a wide variety of quality demands. Organic production contributes with a high level of innovation with regard to new products, processes, market- and company types, as well as to the whole value chain. The innovation that is taking place rubs off on other parts of the market. Basic food products constitute a large proportion of the organic production, but new product types are constantly developed, such as spelt and Öland wheat flour, pearl grains (Nordic rice), that may substitute imported rice, as well as freshly stone ground products from local mills. In addition, new market schemes are developed, such as the food box subscription schemes. The impact of organic production on employment is inconclusive. The more extensive livestock production has a negative effect, while the increased production value and value increment has a positive influence on the employment.

The organic industry can act as a catalyst for social innovation by contributing to better contact between urban and rural communities, knowledge on food products and healthy diet, environmental awareness in general and socio-economic workplaces. More organic farms may create more life in the countryside, positively brand local areas and make the rural areas more attractive to newcomers. Organic farming and processing have an unexploited potential within this area, and it is not necessarily large areas of farmland and intensive production that are considered most important. A great variety of activities and local presence also play a big role for the catalyst effect of organic farming.

It is important to maintain focus on a market-oriented organic production and to achieve a better understanding of what diversity means in a commercial as well as a social context but also to find out how these can be further developed.

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Overall and Cross-Disciplinary Synthesis

Overall, the contribution of organic agriculture to the public goods is determined by the organic objectives, principles and rules on the production methods. However, in practice the impact is mainly caused by the specific legal requirements imposed on organic crop and livestock production. The type of farm – e.g. dairy cattle, pigs, poultry, crop or horticulture production – the size of the farm as well as the farm management also matter, and sometimes the geographical location may influence how the individual farm contributes to different public goods.

In the previous chapters, we have clarified how organic agriculture contributes to the public goods: Nature and biodiversity, environment, energy and climate, human as well as animal health and welfare plus development of industry and rural areas. The laws and action plans regulating the contribution of agriculture to the different public goods have been examined and described as well as the positive and negative contributions of the organic agricultural sector to these goods. The findings have been based on an exhaustive survey of the existing scientific documentation within the above-mentioned areas.

Overall, organic agriculture contributes positively to the public goods. However, when taking a closer look at the individual public goods, a varied picture emerges. The effects of organic farming on nature and biodiversity, including the effects on bees and other pollinators as well as the soil fertility, are predominantly positive. The same applies to animal health and welfare, because the animals have more space, access to outdoor areas, grazing and daily access to roughage. The effect of organic foods on human health and welfare is also estimated as being positive due to the lower contents of pesticides, food additives and drug residues, especially antibiotics that are not used to the same extent in organic as in the conventional livestock production. Furthermore, in general, the diet of "organic consumers" is healthier, as it is more in line with the official recommendations on diet composition. However, when eating organic vegetables, there might be a small risk of being exposed to parasites or disease germs, because the vegetables have been fertilised with livestock manure instead of mineral fertilisers. With regard to the environmental impact of organic farming there are both positive and negative effects depending on the type of farm. The organic dairy farms have lower nitrogen leaching per hectare than similar conventional farms, while the opposite is the case for organic vegetable production and production of organic free-range pigs. In field crop production there are no significant differences between the two farming systems.

The impact of organic production on the public goods, energy and climate or development of industry and rural areas cannot be expected to be substantial. As regards energy and climate, only a few overall organic principles have been formulated in the EU Organic Regulation, (EC) 834/2007 and no specific rules exist. As regards the effect of organic agriculture on energy consumption and climate changes only limited documentation is available. In general less energy is spent and less greenhouse gasses are emitted per hectare in organic agriculture compared with conventional agriculture, because the production is more extensive. However, when calculated per produced unit the energy consumption may be higher for some types of production, for example slaughter pigs and egg laying hens. The emission of greenhouse gas per kg product is generally higher for organic animal products compared with conventional animal products, but the variation between individual farms is large – from positive to negative. The effect depends to a great extent on the type of farm and on the individual product. The difference in carbon sequestration that arise from differences in the crop rotation and crop composition is usually not included in the calculation of greenhouse gas emissions, as this is very difficult to measure.

The development of industry and rural areas has been described as an intention of organic farming in the EU Organic Regulation but this is not addressed as such in the Danish organic legislation. The effect of organic production on this public good is unclear and not well documented. However, the organic rules and principles as a whole have proven to inspire many innovative activities in the entire organic value chain. As good examples the cooperation between Gram Castle and Rema 1000 and other similar local partnerships between producers, processors and/or retail should be

Positive effects and synergies	Organic rules	Negative effects and dilemmas
Greater biodiversity and more pollinators, environmental protection of ground and surface waters, lower risk of negative effects on human and animal health, innovative development of mechanical and automated weed control	Only a few non-synthetic pesticides are allowed	Reduced yield per hectare. Mechanical weed control increases the risk of N-leaching and CO_2-emmission
Greater biodiversity for plants and animals, more pollinators and useful insects, increased carbon storage and soil fertility, less leaching of nitrate from clover grass pastures on dairy farms	Multi-annual, varied crop rotations with legumes and green manure crops	Greater share of spring sown crops and ploughing under of clover grass pastures increase the risk of higher nitrate leaching and emission of nitrous oxide
Greater biodiversity in the farm soil, increased soil fertility, increased carbon storage, lower N-application, lower P-surplus and nitrate leaching on dairy farms, lower energy consumption per hectare for fertilisation, possibly more beneficial plant substances	No inorganic N-fertilisers, only organic N-fertilisers - especially animal manure Max. 170 kg total N/ha - in practice lower application due to the organic subsidy scheme requirement of max. 100 kg utilisable N/ha	Unbalanced fertilisation compared to the needs of the crops causes lower yields, risk of nitrate leaching and ammonia volatilisation as well as risk of higher emission of greenhouse gasses
More home-produced feed and more legumes in the crop rotation save import of protein rich feed and N-fertiliser, innovative development of bio-refinery plants	Ban against synthetic ammonia acids	Excess of protein in the feed of pig and poultry herds due to an unbalanced amino acid composition leads to increased risk of N-leaching due to increased N-content of the manure
Improved animal welfare, fewer leg and respiratory diseases. Lower emission of greenhouse gases for animal products per hectare expect for beef	Larger area per animal outdoors and in the stable	Higher energy consumption per animal in the stable and higher emission of greenhouse gasses for animal products per kg product
Improved animal welfare, less leg and respiratory diseases, lower mortality for dairy cattle, greater biodiversity, nature management, lower N-leaching on dairy farms, improved fatty acid composition in animal products, less use of antibiotics	Ruminants grazing on pastures during the summer half year	Higher mortality for calves and more parasites
Improved animal welfare, less leg and respiratory diseases, less use of antibiotics, higher product quality, innovative designs of poultry runs and sow fencings	Access to outdoor areas for pigs and poultry	Larger area requirement per animal increases the risk of higher ammonia volatilisation and leaching of nitrogen. More parasites, higher mortality of suckling piglets, due to the sows giving birth in huts outdoors
Improved human health due to less use of antibiotics in animal production, lower risk of antibiotic resistant pathogenic bacteria	Restrictive medication including use of antibiotics	Risk of late or ineffectual medication of sick animals

Figure: Examples of positive effects and synergies as well as negative effects and dilemmas due to organic requirements in relation to different public goods.



mentioned, as well as different ways of selling local food products, farm shops, food communities, organic versions of new Nordic food, etc.

As already mentioned, the contribution of organic agriculture to some of the public goods depends on the type of farm. The organic dairy farms have lower nitrogen leaching than conventional farms, while the nitrate leaching from organic pig farms is higher. The effect in relation to other public goods may depend on the size of the farm or its geographical location. The field size and the duration of organic cultivation of the fields are important for the contribution to nature and biodiversity, while the geographical location of an organic farm determines whether it contributes to the protection of surface and ground water against pesticide contamination.

Some organic requirements in the regulation and production systems contribute positively to more public goods at the same time – and consequently create a form of synergy. Thus, the ban on almost all pesticides has positive effects on the nature close to the fields and on the biodiversity of the flora and fauna as well as the soil microorganisms. The same applies to the environment, because pesticides in the surface and ground water are avoided. The pesticide ban also has positive effects on the important ecosystem functions, to which the biodiversity contributes, such as the soil fertility, pollination and biological pest control. It may also prove to have a positive effect on the health of humans and animals, but at present there is no clear evidence for that (see figure).

Other requirements cause conflicting contributions. On the one hand, the requirement that sows must have access to grazing contributes positively to animal health and welfare in the form of fewer leg problems and natural behaviour of the sows. On the other hand, the requirement contributes negatively to the mortality of piglets, which die in higher numbers accidently crushed by the sow in the relatively small huts, where supervision is difficult. There is also negative environmental impact due to point pollution from the manure. The organic principles thus hold a number of inherent dilemmas in relation to the effect on the different public goods, because the objectives of the organic production method are so multifunctional.

In the legislation and the political action plans that aim at improving or sustaining public goods, focus is often primarily on one or a few effects of the instruments used for agriculture. This applies among other to the water protection plans or the action plan to prevent antibiotic resistance. Seen in isolation, the individual effects of organic production may cause a smaller improvement, and other instruments may be more efficient. On the other hand, when looking at the total effects of organic production on a variety of public goods there are great opportunities to utilize the synergies of the organic contributions and obtain a coordinated effect in relation to the objectives of several public goods at the same time.

In its report from 2013 the Danish Nature and Agricultural Commission[1] stressed that increased measures should be taken to support organic farming, among other things due to the significant positive contributions of organic production to the solution of key nature and environmental policy challenges (Recommendation 27). However, at the same time, the report points out that organic agriculture faces challenges regarding emission of greenhouse gasses and ammonia among other things.

The evaluation report 'Den økologiske vej mod 2020' (The Organic Road towards 2020)[2] carried out by the consultancy company Operate for the Danish Ministry of Environment and Food in 2014, included three recommendations regarding the role of organic agriculture in the future in relation to the public goods:

- Denmark should include organic production as a means of reaching relevant societal goals.
- Denmark should ensure that support to the agricultural sector is based on an evaluation of the usefulness of the production to the society.
- Denmark should ensure that a significant part of the research efforts takes as its starting point the basic needs of the organic sector – including the development of scientific methods for the documentation of the value creation of organic production in relation to the needs of society.

In the coming years there is a need to take a closer look at the organic principles, which lay down the framework for the contribution of organic farming in relation to the public goods. Some of the organic principles have not yet resulted in specific rules. For example, there are no direct requirements regarding energy consumption, emission of greenhouse gasses or carbon sequestration. Neither are there any direct requirements for management of the nature, while measures for improving biodiversity, animal welfare and the environment are much more regulated. Thus, the greatest effects of the organic cultivation method are also seen here. If organic agriculture continues to develop in accordance with the organic principles, there is a great potential for improvement of its contributions to some of the public goods, on which organic farming does not have a positive effect today, or where the effect can be improved even further.

1 file:///C:/Users/lmj/Downloads/3621_NaturLandKomm_Slutrapport_1104_Links%20(1).pdf

2 http://fvm.dk/fileadmin/user_upload/FVM.dk/Dokumenter/Landbrug/Indsatser/Oekologi/Den_oekologiske_vej_mod_2020.pdf

This applies e.g. for animal welfare and the environment as well as for energy and resource efficiency. It is probably more difficult to strengthen the development of the industry and rural areas by means of the organic legislation, but here other incentives may be used, e.g. rural development and environmental support programmes or the like.

More organic agriculture and a larger organic production are needed to be able to utilise the full potential of organic agriculture for contribution to the public goods. At the moment the demand for organic products is increasing rapidly in Denmark as well as on the export markets, which forms a good basis for a continued growth of the organic farm area. In recent years conventional farmers have been reluctant to convert to organic production, among others due to the financial crises. However, in 2015 over 22,000 hectares were converted into organic farming area, an increase of more than 10 percent.

The principles and the specific requirements for organic production motivate the organic farmer to lead the way and experiment with new solutions that ensure not only the delivery of organic products of a very high quality but also contribute to the public goods. As examples of this can be mentioned robots for mechanical weed control, more animal and environmentally friendly poultry runs and sow enclosures, organic food box concepts and food communities, development of new dairy products, more eco-friendly production methods and packaging, farm shops, eco-tourism, etc.

Also in organic research, development and extension service projects are carried out that may improve the contribution of organic farming to the public goods and solve some of the integrated dilemmas. Agriculture in general will also be able to make use of these solutions. In two of the research and development projects coordinated by ICROFS, the work is focused on the development of bio-refinery facilities that can transform organic green crops into protein, fertiliser and energy. This new technology may lead to self-sufficiency of organic protein feed for hens and pigs, better crop rotation with more carbon sequestration in the soil, greater biodiversity, more renewable energy and higher yields.

Overall, this may result in a better climate profile, a lower resource consumption and better animal health on the organic farms that use this technology. With such facilities it will also be possible to reduce the import of soy protein – also in conventional farming.

If the ability of the organic production methods to deliver public goods is brought into focus to a greater extent, increased demands will be placed on the organic farm manager. This may result in a change of the structure in organic agriculture in the future, which mainly will be towards larger, more commercial and business like farms. In that case it will be even more important to hold on to the organic principles and extend the regulations – especially regarding sustainability and biodiversity.

However, most likely there will still be smaller farms that are farmed organically because of a special interest in the organic farming method, and they should not be forgotten in the future development. These farms may contribute with many new ideas enabling the development of the organic production, just as they may make it more attractive to live in the countryside, e.g. because of the opportunity for people to buy locally produced food products of high quality.

A strengthened contribution of organic agriculture to all of the above-mentioned public goods requires further research, development, documentation of and consultancy on how the organic principles can be put into practice in the best way on different farm types and farm sizes. Another requirement is that the organic producers maintain the ability to continuously improve the organic production method and create innovation in the rural areas. Finally, communication on and education in organic food production should be maintained and expanded in order to ensure a broad understanding of best practices in organic agriculture in relation to where and how organic agriculture may contribute to public goods.

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